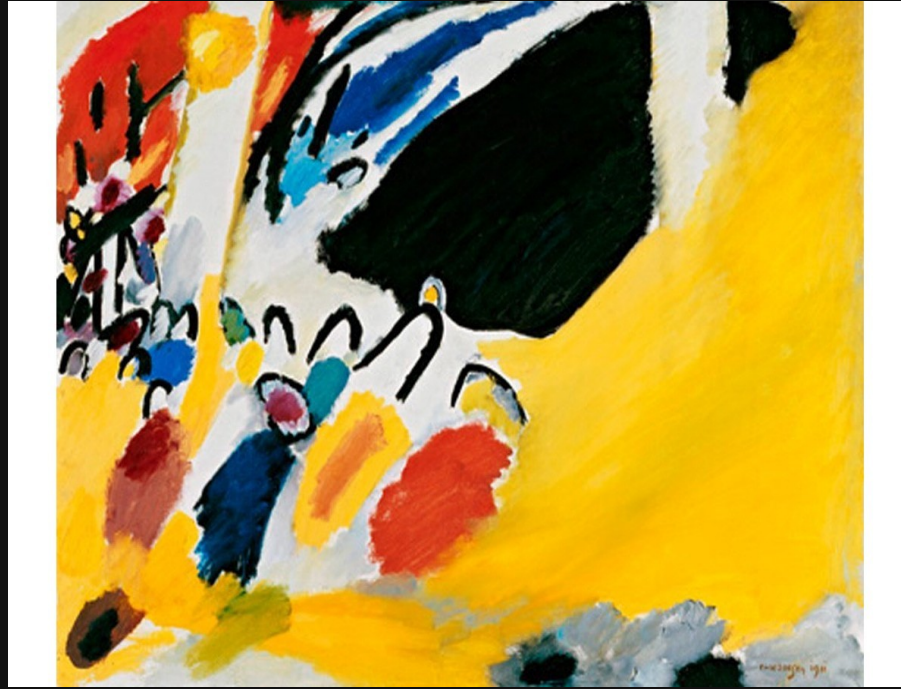




Listening as one:
from **collective motion** to **collective experience**

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Acknowledgements



Prof Henrik J Jensen

Dr Takayuki Nozawa

Portorius Quartet

Prof David Dolan

Dr Hardik Rajpal

Dr Pedro A M Mediano

Dr Fernando E Rosas

Alberto Liardi



*(paintings in this presentation are by Vassily
Kandinsky and Ursula Gullow)*

“

In all societies, a primary function of music is collective and communal, to bring and bind people together. People sing together and dance together in every culture [...] in such a situation, there seems to be a binding of nervous systems accomplished by rhythm.

— Oliver Sacks



Cognitive processing of a common stimulus **synchronizes** brains, hearts, and eyes.

Physical synchrony between humans facilitates rapport and learning.

Group flow states encourage teamwork and cooperation.

A crowd of people at a concert, silhouetted against a bright, colorful background of blue and purple light. Many hands are raised in the air, some with fingers spread, suggesting a lively atmosphere.

An **embodied** and **enactive** approach suggests that movement, cognition and experience are intrinsically linked.

We study **movement** as a proxy to understand **experience**.

WHAT IS IT LIKE?



MUSICAL IMPROVISATION



1800s



1900s



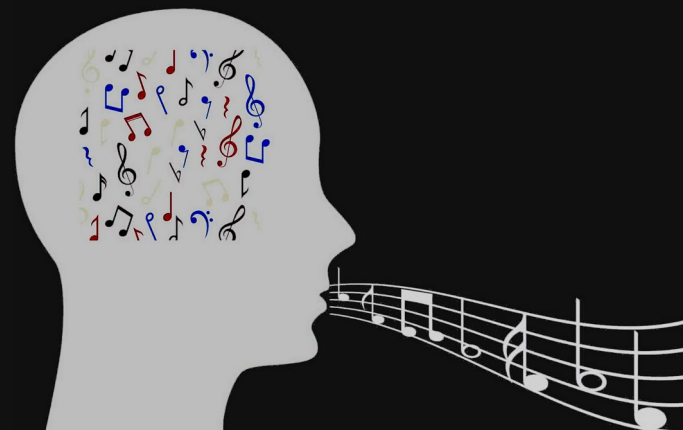
2000s

MODES OF PERFORMANCE



Strict

control technical precision, timing and accuracy of the score's details and avoiding risks



Let-go

play freely, spontaneously, by coordinating with partners and applying an improvisational state of mind

THE IMPROVISATIONAL STATE OF MIND

Performers and **audience** show increased Lempel-Ziv **complexity** during let-go and improvisation.



Is the **improvisational state** also a **collective shared experience**?

THE CONCERT EXPERIMENT PARADIGM



Playing a repertoire piece **strict** or **let-go** allows direct comparisons of performance parameters, audience behaviour and the performers' and audience's brain signals.

EXPERIMENTAL SETUP

The **Portorius String Quartet** played 2 repertoire pieces in **strict** & **let-go** modes:

Mozart's String Quartet KV. 421 no. 15

Haydn's String Quartet Op. 76 no. 1, III

Data collection:

- Head motion sensors for performers
- Smartphone accelerometers measuring body motion for audience members
- Psychometrics and questions about the performance



SYNCHRONY AS WAVELET COHERENCE

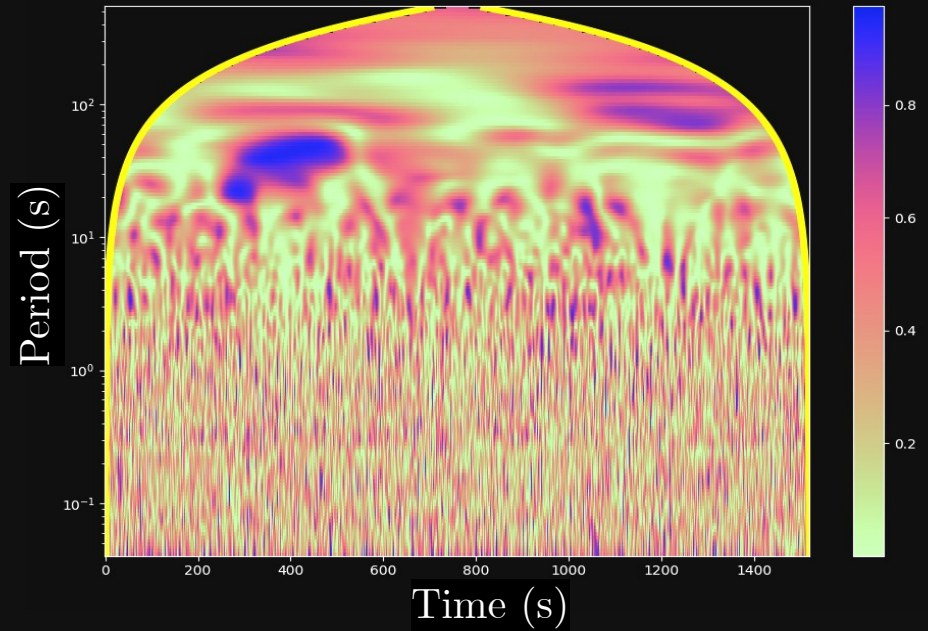
Compute synchrony between performers and audience (**P-A sync**) and between audience members (**A-A sync**) in pairs, then average.

Wavelet coherence transform:

compute wavelet coefficients of each motion signal, then calculate correlations between them (amplitude: real part; phase: imaginary part)

Data-agnostic: can be applied to synchrony between movement and music too.

$$W(t, s) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} x_u \bar{\psi}\left(\frac{u-t}{s}\right) du$$

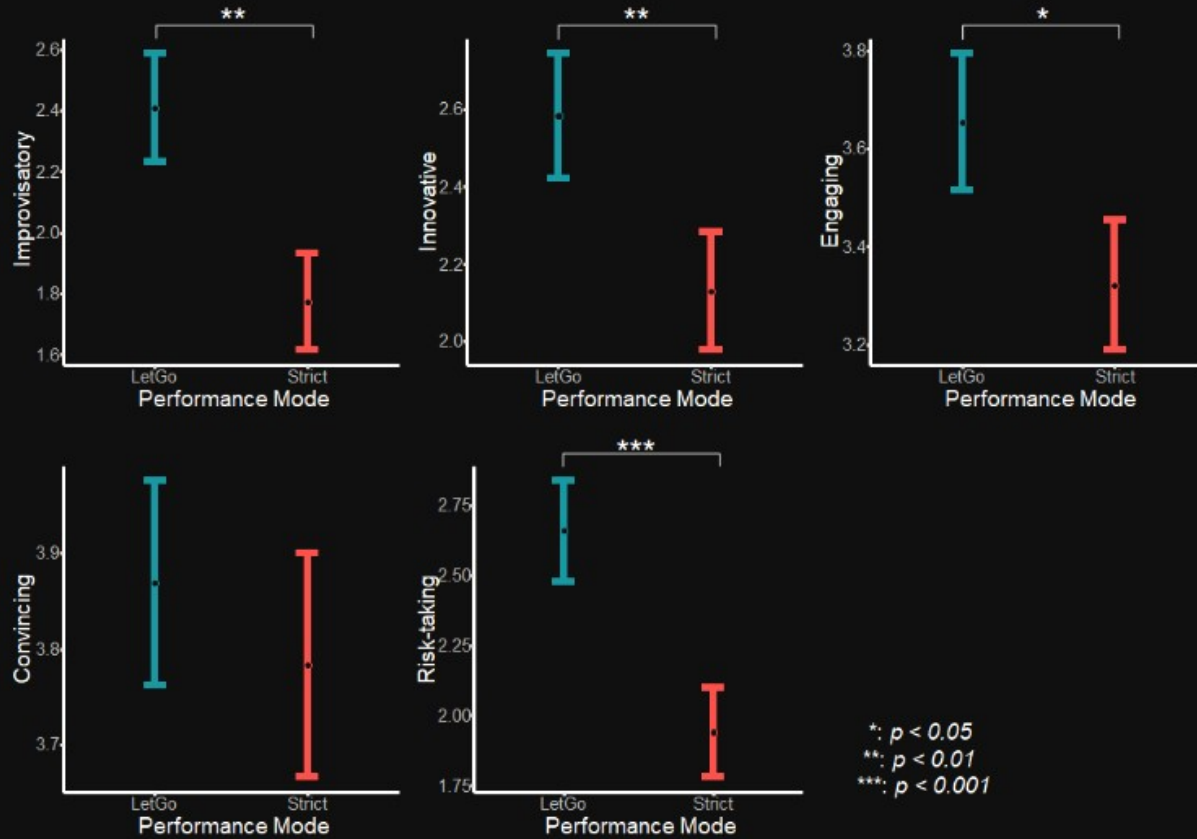


THE MUSICIANS' PERSPECTIVE

... the let-go version puts us on an awareness edge, and suddenly we are able to see past the music and look out for these spontaneous cues for the changes in both the music itself and the way we perform it...

... a very high level of mind-reading and synchronicity ...

THE AUDIENCE'S PERSPECTIVE



THE AUDIENCE'S PERSPECTIVE



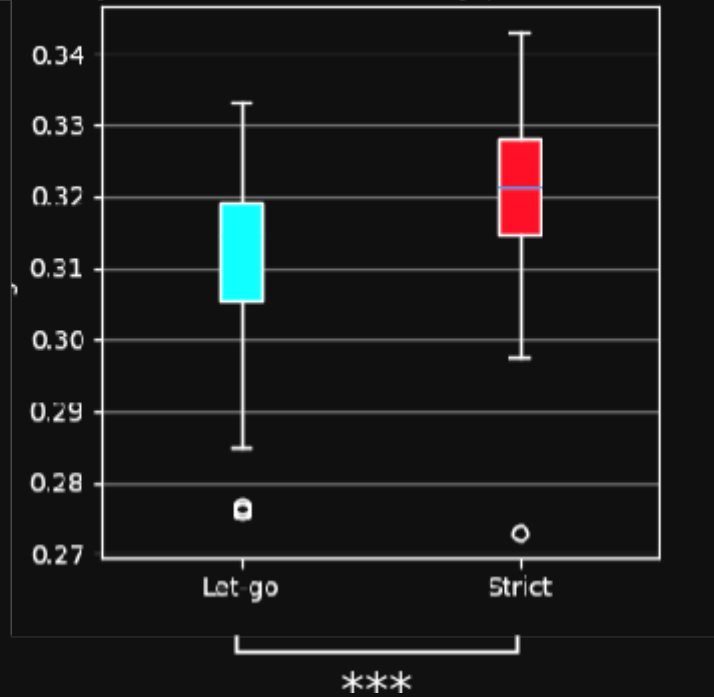
Classical music audiences show higher synchrony of movements, heart rate and arousal when listening.

Synchrony facilitates many prosocial behaviours.

But synchrony decreases as enjoyment of the piece increases?

COLLECTIVE MOVEMENT

Per subject overall coherence by performance mode



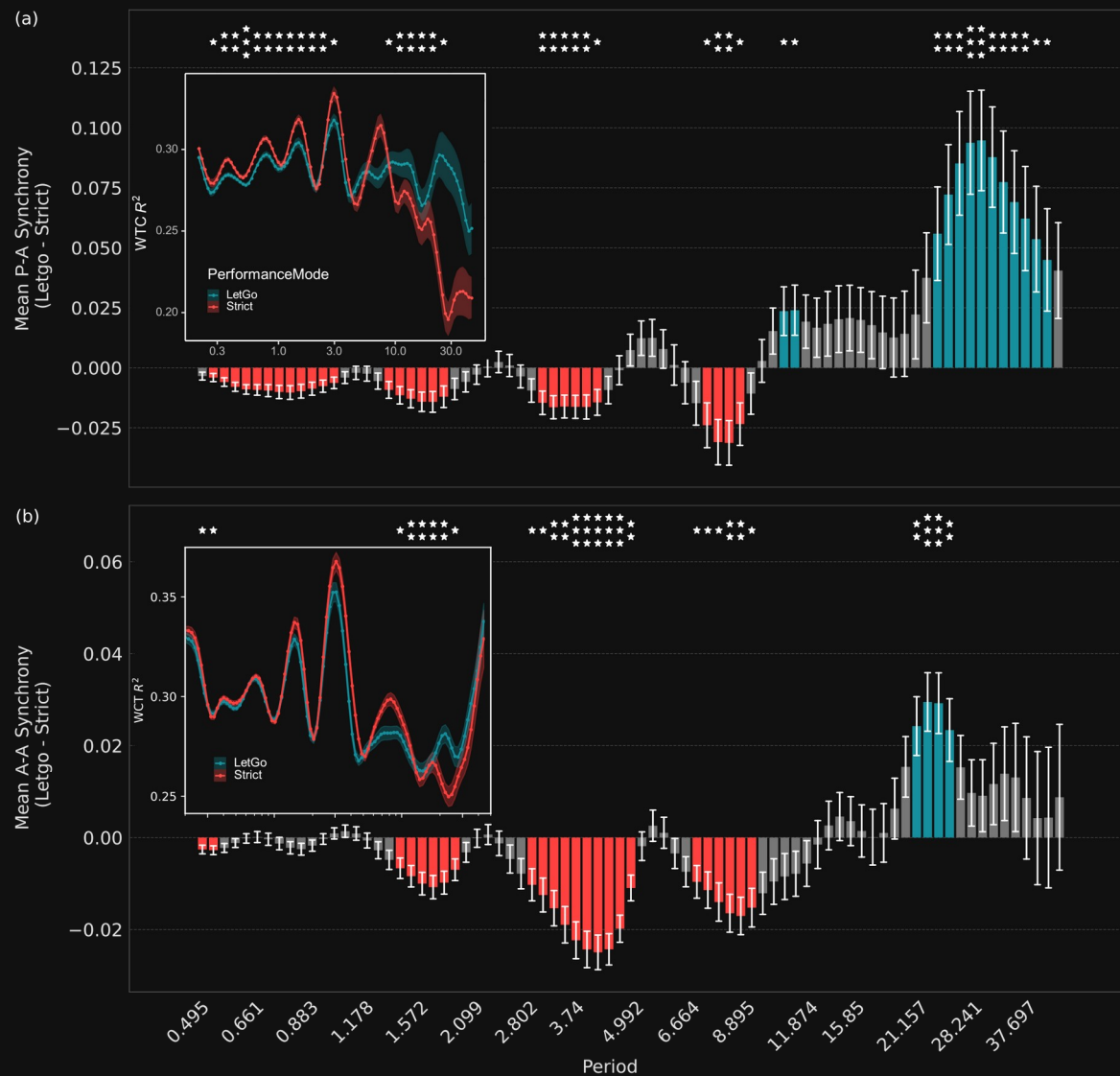
Overall, audiences synchronise their body motion more in **strict**,
but they enjoy **let-go** more?

But when unfolded...

Both **P-A sync** and **A-A sync** show a **multiscale** regime:

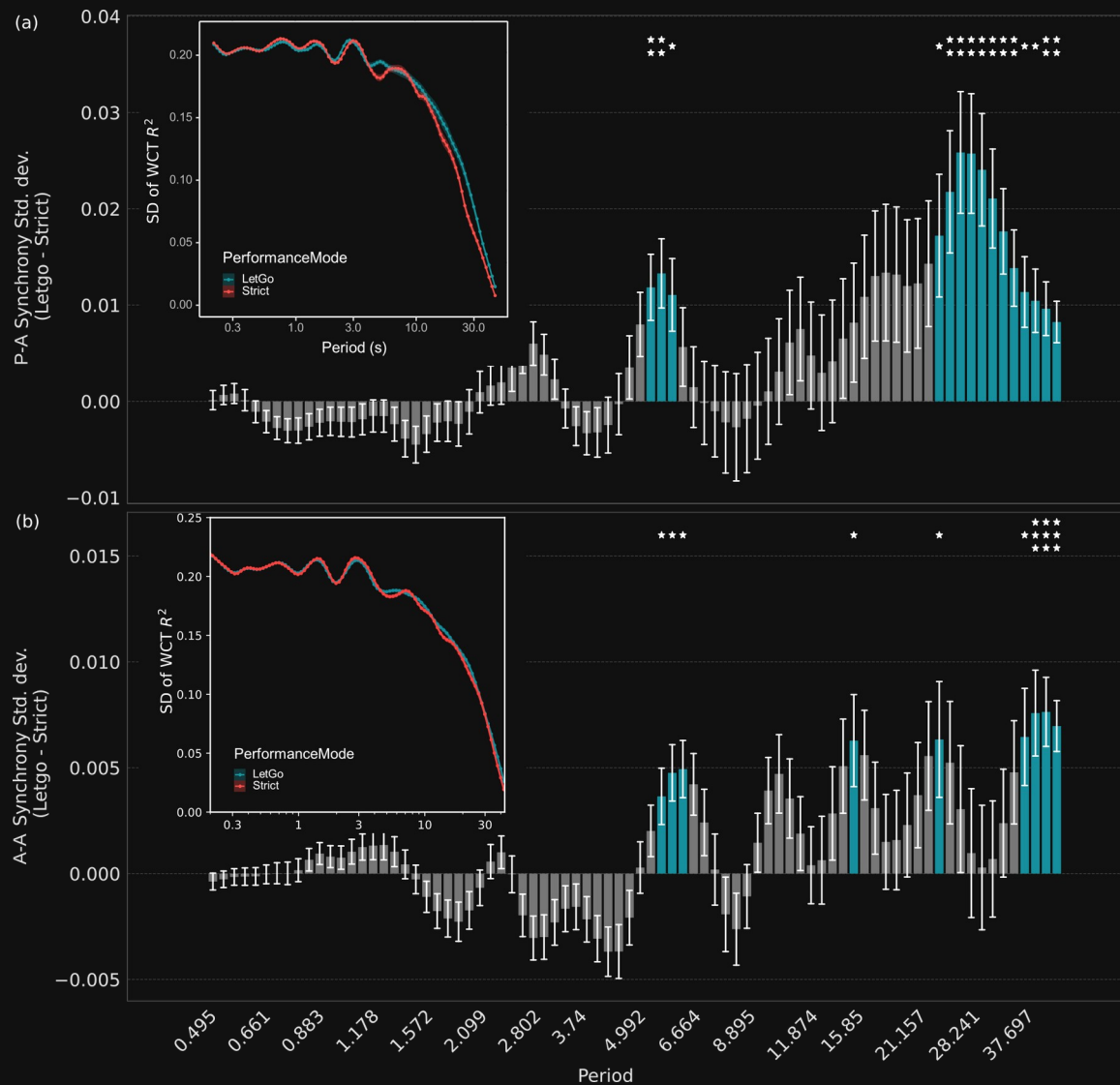
Under 10 seconds, significantly more sync in **strict**, matching the rhythmic elements of the music

Over 10 seconds, significantly more sync in **let-go**, matching long musical gestures and narrative elements of the music

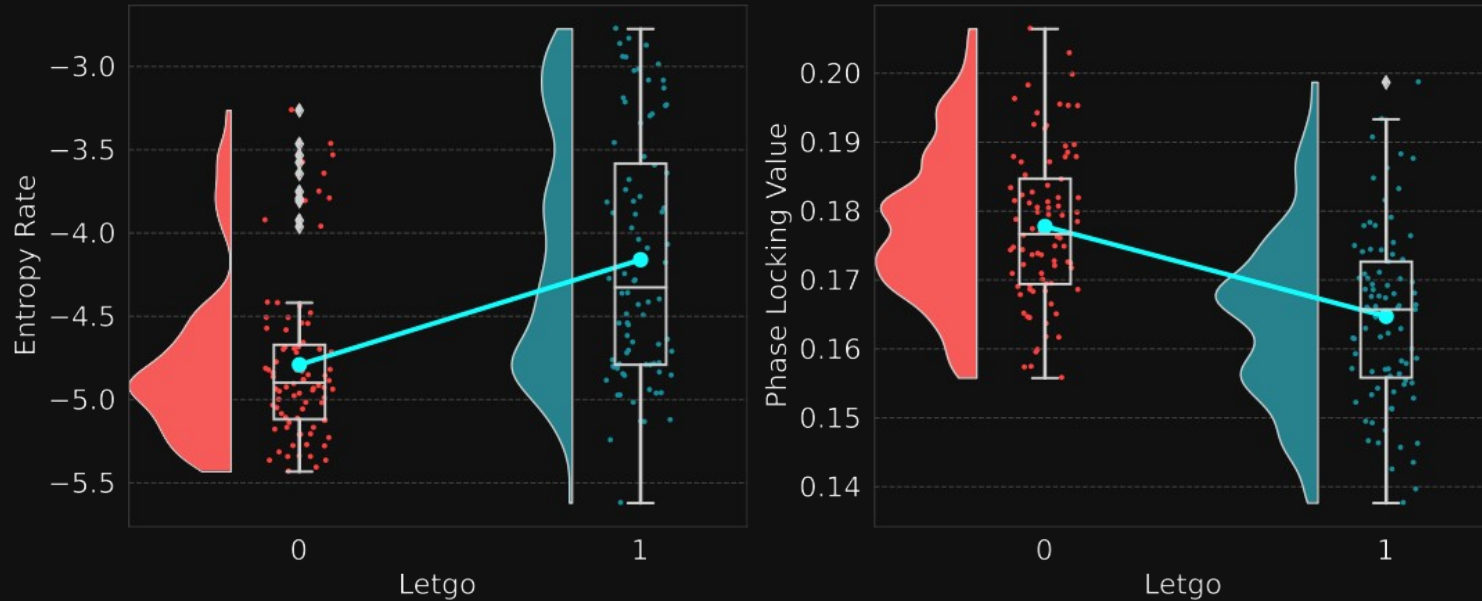


Variability consistently higher in **let-go** both for **P-A sync** and **A-A sync** suggesting adaptation and metastability.

Strongly associated with perception of **risk-taking**.

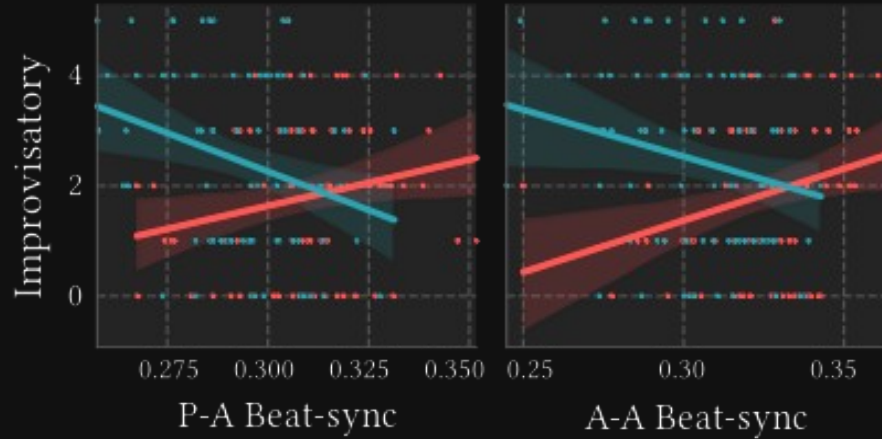


COLLECTIVE BREATHING



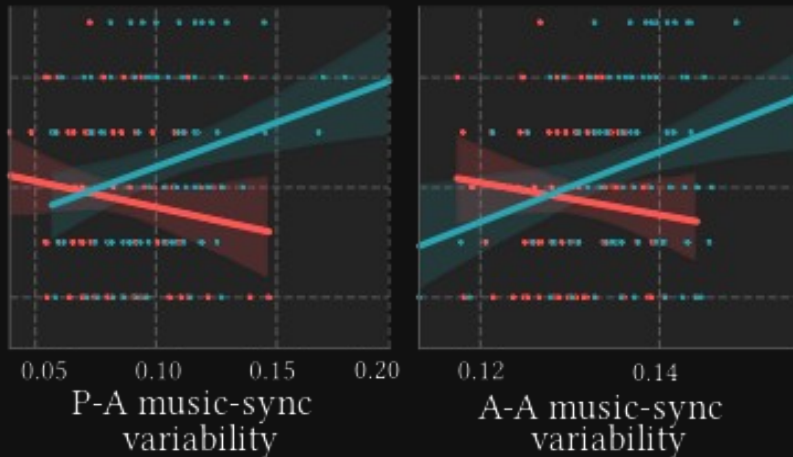
Audiences show higher breathing synchrony in **strict**,
but more complex breathing patterns in **let-go**.

COLLECTIVE EXPERIENCE



Higher sync in breathing and short-term movements (**beat-sync**).

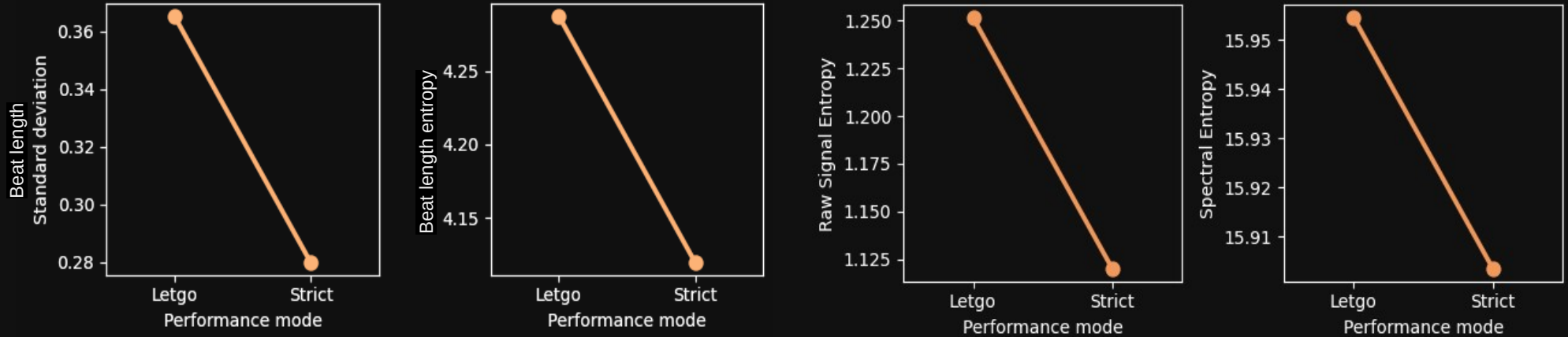
Enjoyment is associated with the long-term (**music-sync**) high synchrony.



The perception of risk-taking is related to higher temporal variability in long-term synchrony.

Multi-scale sync seen in other performer-audience collective motion.

QUANTITATIVE DIFFERENCES IN MUSIC



Average length of a beat, bar or musical gesture matches the significant peaks in synchrony.

The **let-go** mode produces more variability in tempo and dynamics and higher tempo, raw signal and spectral entropy (related to timbre) than **strict**.

CLOSING THOUGHTS

The multimodal paradigm of the concert experiment with strict and let-go mode allows a perfect laboratory for studying experience.

Differences in movement and music mirror differences in subjective experience in both performers and audiences.

The multiscale synchrony reveals a continuous entrainment between audience and performers, and differentiates collective experience.

THANK YOU!



AND HAPPY (EARLY) BIRTHDAY HENRIK!